POTATO DISEASE AND INSECT CONTROL WITH - LOW-GALLONAGE SPRAYERS

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Cover Picture—The sprayer shown on the cover is one of the low-gallonage sprayers tested during the 4-year study on low-pressure, low-gallonage, high concentration sprayers. These sprayers were compared with conventional high-pressure sprayers, both trailer type and tractor-mounted. The cover picture was taken at the experimental plots at the Maine Agricultural Experiment Station's research farm at Presque Isle, Maine, in July, 1952, by Dr. Reiner Bonde. Note the long drop pipes shown in the cover picture. These are recommended for use with low-gallonage sprayers.

SUMMARY

Sprayer studies by the Maine Station show that the low-gallonage, high concentration method of applying fungicides and insecticides to potatoes for disease and insect control is practical, and that it has certain advantages over the conventional high-pressure method.

The chief advantages are the lower initial cost of the low-pressure machines and their subsequent lower operating costs, since they require less water for spraying. Also, the low-pressure machines may be useful for weed control and for potato vine killing prior to digging and harvesting. There is the advantage too, that since low pressure machines are trailer type, they are quickly hitched and unhitched from the tractor, freeing it for other farm operations. Some farmers prefer low-pressure sprayers for that reason.

The studies on the low-pressure machines—made over a 4-year period, 1949-53—indicate that the low-pressure sprayer will probably not give better control of potato diseases and insects than the high-pressure sprayer. However, the experiments have shown that good commercial control of late-blight and insects can be obtained with the low-pressure sprayers providing the applications are begun early in the season and are made often enough to keep the foliage well covered with spray when conditions are favorable to diseases and insects.

A tractor-mounted, low-pressure sprayer was used experimentally in 1953. Although late blight was not prevalent that year, tests of this machine indicated it also is satisfactory for spraying potatoes.

Fungicides or insecticides in the form of wettable powders were not suitable for the low-pressure machines used in the experiment. However, the liquid fungicide Nabam and the insecticides DDT and parathion oil emulsions were well adapted for spraying potatoes with the low-pressure machine. The concentration of the spray mixture was four times (4x) that used for the conventional high-pressure machine.

The use of long drop pipes on the spray boom of the low-pressure sprayer gave better coverage of the materials on the plant and increased the control of aphids.

There was no significant difference in the yields of potatoes was a result of using either of the two kinds of sprayers.

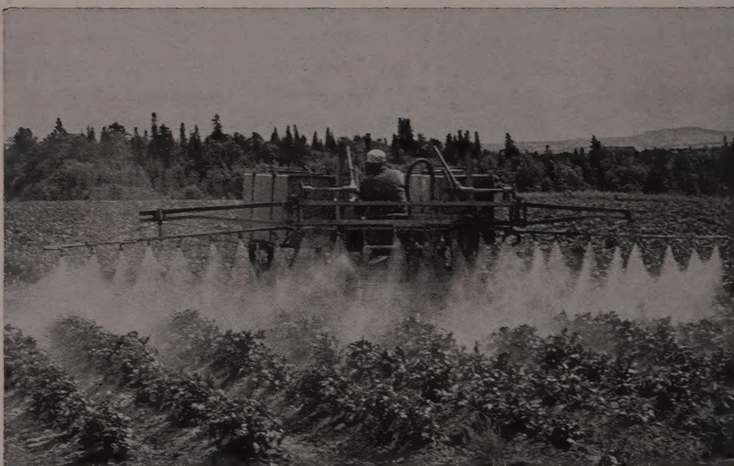

Fig. 1. A tractor-mounted, high-pressure sprayer in operation in Aroostook County, Maine. This type of sprayer was compared with the newer low-pressure, high-concentration sprayers for control of disease and insects.

POTATO DISEASE AND INSECT CONTROL WITH LOW-GALLONAGE SPRAYERS

Frank W. Peikert and Reiner Bonde[1]

INTRODUCTION

Since spraying for control of potato diseases and insects is costly, many potato farmers have been interested in obtaining spray equipment which is lower priced and cheaper to operate than the conventional high-pressure sprayers now generally used.

Low-pressure spray machines, which use only about 25 or 30 gallons of water an acre to apply the fungicides and insecticides, have been successfully used for the control of weeds in Maine for a number of years (5, 6, and 8).[2] Recently, interest has developed in the use of similar equipment for the control of potato diseases and insects. The fact that many farmers failed to control late blight during the severe epidemic of 1951 with some of the equipment then in use helped stimulate interest in low-pressure, high-concentration sprayers and a rather large number came into use in 1952 and 1953.

Simultaneously, tests were being conducted by the Maine Agricultural Experiment Station (for the past four years) to compare the newer low-pressure, high-concentration sprayers with the conventional high-pressure sprayers for their effectiveness in the control of potato diseases and insects.[3]

As a part of the study, a number of potato growers were contacted in 1952-53 to determine their success with the low-pressure machines. In general, they have been satisfied with the control obtained on insects. (During these two years there was very little late blight. Therefore, the growers have not had experience with these machines during a season in which the disease was prevalent.)

This bulletin summarizes the test data and other information available comparing low- and high-pressure spraying of potatoes in Maine. Other information on this subject has been presented in Mimeographed Reports No. 18, 24 and 33 of the Maine Agricultural Experiment Station (1, 2 and 3).

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[1] Head, Dept. of Agr. Engineering and Plant Pathologist, respectively.

[2] Numbers in parenthesis refer to Literature Cited, page 17.

[3] The following companies cooperated in this project by furnishing equipment used for test purposes and their assistance is gratefully acknowledged:

1. Moulton and Goodwin, Portsmouth, New Hampshire
2. Maine Potato Growers, Inc., Presque Isle, Maine
3. H. D. Hudson Manufacturing Co., Chicago, Illinois

EQUIPMENT USED IN TESTS

In these tests comparisons were made between pull-type, low-gallonage sprayers which applied 25 to 30 gallons per acre at a pressure of 75 to 80 pounds per square inch and a conventional high-pressure sprayer which applied 100 to 120 gallons per acre at 400 pounds per square inch.[4] Travel speed in all cases was four miles per hour.

Two low-pressure machines of similar design were used during the four years of tests; both were trailing types with 8-row booms and one-cylinder engines. (See cover picture.) The type of high-pressure sprayer used is shown in Fig. 1.

For the 1950-1952 seasons the low gallonage test sprayer was a Hudson "Peerless." It had a pump capacity of 5 gallons a minute and was driven by a 2½ horsepower engine. The operating pressure was kept as nearly as possible to between 70 and 80 pounds per square inch. The machine had a 100 gallon tank, although most of the sprayers used in the area had 150 gallon capacity.

In the 1953 tests a GP Model Myers sprayer was used. It had a pump capacity of 7 gallons a minute and was driven by a 4 horsepower engine. The operating pressure was maintained at 80 pounds per square inch. This particular machine had a 100 gallon tank; however, it is also obtainable with a 200 gallon tank.

Both low-pressure machines had three nozzles per row. The longest drop pipes possible were used and were arranged so that each row had a nozzle directly above it and a nozzle on each side.

In 1953 another series of plots were sprayed with an 8-row, tractor-mounted unit. This sprayer had a power-take-off pump with about 5 gallons a minute capacity at 80 pounds per square inch, a 50 gallon tractor-mounted tank and the same boom as that used on the pull-type Myers GP sprayer. This boom was mounted on the front of the tractor.

ADVANTAGES OF LOW-GALLONAGE SPRAYERS

The advantages of low-gallonage, high-concentration sprayers over the conventional machines are:

1. Lower original cost. At present it is about one-half that of high pressure sprayers.
2. Three-fourths less water is used. This may be an important factor where water is limited or must be hauled a considerable distance to the field.

[4] The conventional sprayer was an 8-row, tractor-mounted type built by F. Harold Haines of Presque Isle, using a Myers pump.

3. Lighter in weight. Operated under lower pressure and having a smaller tank, it can be built considerably lighter throughout. The result should be less packing of the soil when compared to a heavier conventional pull-type machine carrying larger loads of water.
4. Less power required per acre in applying spray materials. With its lower operating pressure, it requires less power for pumping, whether driven from a separate engine or from power-take-off. The power needed to pull the lighter weight machine through the fields is also less.

SPRAY MATERIALS

The distinctive feature of the low-gallonage sprayer is that it requires about one-fourth as much water as the conventional machine in applying about the same amount of spray material per acre as the high-pressure machines. The conventional-type sprayer now generally used applies from 100 to 120 gallons per acre, whereas, the low-gallonage machine applies from 25 to 30 gallons per acre with four times the concentration of spray chemicals.

Experiments conducted in Maine (2) and New York (4, 7) have shown that powdered fungicides were not adapted for low-pressure, high-concentration spraying since they clog the sprayers screens and nozzles. Nabam with 25 per cent DDT oil-emulsion was found to be well adapted to this type of sprayer and caused no apparent burning or damage to the foliage even when applied at a concentration of more than four times that used in the conventional spray program. (Nabam is chemically known as disodium ethylene bisdithiocarbamate and is sold under the trade names Dithane D14, Parzate, Thiodow and others). The material and concentrations used in the two types of sprayers are given in Table 1.

Zinab, cuprous oxide, and tribasic copper sulfate also were used in experiments conducted in Maine and were found to be less satisfactory

TABLE 1

Concentrations of Chemicals for Low- and High-Pressure Sprayers

Type of sprayer	Chemicals in 100 Gallons			Gallons applied per acre
	Nabam[1]	Zinc sulfate	DDT 25% oil emulsion	
Low pressure	8 qts.	3 lbs.	4 qts.	25-30
High pressure	2 qts.	¾ lb.	1 qt.	100-120

[1] Chemically known as disodium ethylene bisdithiocarbamate and sold under the trade names Dithane D14, Parzate, Thiodow, and others.

than the liquid fungicides. Clogging of the strainers was partially corrected by using 50-mesh-per-inch strainer screens.

Many growers now employ the low-pressure machine for the control of weeds and the tendency is to use the same machine for applying fungicides and insecticides. Growers are cautioned that because of the difficulty of completely removing 2,4-D and similar materials that different sprayers be used for these operations.

Use of Parathion

Preliminary studies conducted at the Experiment Station Research Farm at Presque Isle, Maine, indicate that good control of aphids may be obtained with parathion applied with a low-pressure machine. Information obtained from a number of growers also indicates that very satisfactory aphid control was obtained with low-pressure equipment when 1 pint of 25 per cent parathion oil emulsion was applied per acre in combination with Nabam fungicide.

DISEASE AND INSECT CONTROL

Control of Late Blight

Conditions for late blight spread were favorable in 1950 and 1951, and the latter year has been considered by many as having been one of the most severe late blight years in the history of the State. However, weather conditions during 1952 and 1953 were not favorable for rapid spread of late blight.

Both machines gave complete control of late blight in 1950, 1952 and 1953 when the prevalence of the disease varied from a relatively light infection to a heavy and very destructive infection. The fact that good control was obtained in 1950 demonstrates that low-pressure, high-concentration spraying has considerable merit. However, in 1951 when the disease was very severe the disease control obtained with the low-pressure machine was somewhat inferior (97.0%) to that obtained with the high-pressure equipment (98.8%). The information available indicates that good commercial control of late blight can be expected with the low-pressure machine providing the fields are sprayed frequently and the foliage is well covered with the fungicide. Table 2 compares the two types of sprayers for late blight control for the 4-year period 1950 to 1953 inclusive.

Complete control of late blight requires that the plants be well covered with fungicide, especially during the periods when the conditions are favorable for its spread. Due to the fact that the low-pressure machine may not force the spray onto the bottom leaves, it is necessary to commence spraying while the plants are still quite small rather early

TABLE 2

Comparison of Control of Late Blight for Low- and High-Pressure Sprayers
1950-1953

Year	General conditions for late blight development	Per cent late blight foliage infection[1]		
		Low pressure	High pressure	Control plots
1950	Favorable most of season	0	0	50-60
1951	Very favorable entire season	3	1.2	100
1952	Unfavorable, but destructive late in summer	0	0	5-50
1953[2]	Very unfavorable. Nearly absent	0	0	10-25

[1] Determinations made according to R. W. Barratt and J. G. Horsfall, "An Improved Grading System for Measuring Plant Diseases." Mimeographed sheets.
[2] The spread of late blight was encouraged by artificial inoculation.

in the season. It also may be desirable to spray more frequently with the low-pressure machine during those periods when the plants are growing most rapidly. The number of applications per season for the experimental plots was 9 in 1950 and 1952, 13 in 1951, and 11 in 1953. Insofar as possible the high-pressure spray applications were made the same number of times and on the same dates.

Control of Early Blight

The control of early blight may be a problem some seasons, especially when potatoes are grown for several years in succession in the same fields or when the plants are maturing early because of lack of fertility or water. It is essentially a disease which affects plants when they are maturing and applications of fungicides may have little value. It has been observed, however, that the disease is less prevalent when the fields are sprayed with a spray mixture which stimulates the growth of the plant and which gives good control of aphids and other insects.

Early blight was relatively unimportant in the experimental spray plots in 1951 to 1953. The disease, however, was abundant in 1950 when the spray plots were in a field which had been in potatoes for the two years previous.

The data obtained in 1950 show that there was 26 per cent defoliation by early-blight in the plots sprayed with the low-gallonage sprayer compared with 22 per cent defoliation in those sprayed with the high-pressure machine. The difference was not significant. The unsprayed control plots were 51 per cent defoliated on the same date (September 2). The data therefore show that the spray applications by either machine reduced appreciably the amount of defoliation by the early-blight fungus.

Control of Aphids

Sprayers and spray mixtures, to be generally used in Maine, must give good control of aphids, flea beetles, and other insects as well as of early and late blight. Comparisons were made during the study on the degree of aphid control obtained by the two kinds of sprayers. The results are summarized in Table 3.

The high-pressure sprayer gave slightly better aphid control in 1950 and significantly better control in 1952, but the low pressure machine was significantly better in 1951 and somewhat better in 1953. Thus, there was no significant difference in the performance of the two sprayers in these experiments regarding the control of aphids when the same liquid fungicides and insecticides were used.

Observations during this study showed that frequently aphids were not killed on the lower leaves of the potato plants. This was attributed to the fact that the spray nozzles were too far from the top of the plants and the pressure was not sufficient to force the spray mixture into the bottom parts of the potato rows and cover the lower leaves. This was especially true when short drop pipes were used on the low-pressure sprayers.

TABLE 3

Comparison of Number of Aphids on Potato Plants Sprayed with Low-Pressure and High-Pressure Spray Machines 1950-1953

Year	Average number aphids per leaf[1]		
	Unsprayed control	Low-gallonage sprayer	Conventional sprayer
1950	35.8	18.9	17.0
1951	280.0	4.4	7.1*
1952	40.1	9.6	4.8*
1953	54.8	20.0	28.5

* Significant at 5 per cent level.
[1] Average of number on 3 leaves from each of 10 plants per replication. Leaves selected at random from top, middle and bottom of each plant sampled. Observations made the third week of August for each year.

The comparisons were made with a high-pressure, tractor-mounted sprayer with conventional short drop pipes and a low-pressure sprayer of the trailer type equipped either with long drop pipes, short drop pipes, or a brush-type boom arrangement. A low-pressure, tractor-mounted sprayer, having a long drop pipe boom was also included for comparison.

Table 4 shows the average number of aphids on the top, middle, and bottom leaves of the potato plants in the different treatments. In this experiment, the plants sprayed with the high-pressure, tractor-mounted sprayer with a short drop pipe boom had the heaviest aphid infestation.

TABLE 4

Comparison of the Number of Aphids on Plants Sprayed with Different Types of Sprayers and Arrangement of Nozzles

Type of sprayer	Type of boom	Number aphids per leaf[1]			
		Top	Middle	Lower	Total
1. High-pressure tractor mounted	Conventional short drop pipes	1.8	6.7	20.0	28.5
2. Low-pressure trailing	Long drop pipes	1.6	3.6	7.4	12.6
3. Low-pressure trailing	Short drop pipes	2.0	5.4	12.6	20.0
4. Low-pressure	Brush boom	1.8	4.4	11.9	18.1
5. Low-pressure tractor mounted	Long drop pipes	2.0	3.2	7.8	13.0

[1] Average of 3 leaves from each of 10 plants per replication. Leaves selected at random from top, middle, and bottom of each plant. August 13 and 14.

There was no significant difference in the number of aphids on the top leaves for the different types of sprayers or nozzle arrangements. In contrast, on the middle and lower leaves, the aphid infestation was reduced when the boom was equipped with drop pipes that carried the spray mixture to the lower parts of the plants.

It should be mentioned that some difficulty was encountered with the long drop nozzles after the potato plants had reached their maximum growth and had begun to fall between the rows in the field. This condition necessitates raising and adjusting the boom and nozzles to secure the minimum amount of interference from the potato foliage.

Control of Flea Beetles

Observations made during this 4-year study indicate that DDT emulsion applied with either low or high-pressure machines produced satisfactory control of flea beetles which cause foliage injury. The injury to the foliage was relatively unimportant in the sprayed fields during the experiments. The injury in the unsprayed check rows was severe in 1950, causing from 45 to 56 per cent defoliation, and rather slight from 1951 to 1953.

Good control of flea beetles was dependent on early applications of DDT for the control of the early brood of the insect, and later application during the latter part of the season for control of the late summer or fall broods. Both types of machines appear to give satisfactory control of flea beetles.

COMPARISON OF SPRAY COVERAGE FOR DIFFERENT DROP PIPES

In 1953 comparative tests were made with the low-pressure sprayer using long drop pipes, short drop pipes, and a brush-type boom.

The long drop pipes were flexible pendants 26 inches long, each with a hose supplying two nozzles which were set so as to cover one side of two rows. Each short drop was made from two pipe pendants 10 inches long with a nozzle directed to the side of the row. The brush boom had all three nozzles per row at the boom level without using any drop pipes.

Comparisons were made both on the coverage of the spray materials as indicated by leaf prints and on the control obtained on aphids. Since there was very little occurrence of late blight, no good measure of disease control could be obtained from the one year's tests.

Distribution of Chemicals

A study of the coverage of spray materials on the potato plants was made for the different nozzle positions. Plots were sprayed and shortly afterwards samples were taken of a number of leaflets at the top, middle, and lower positions of the plants to determine the extent of coverage. These leaflets were pressed between chemically treated filter paper to get

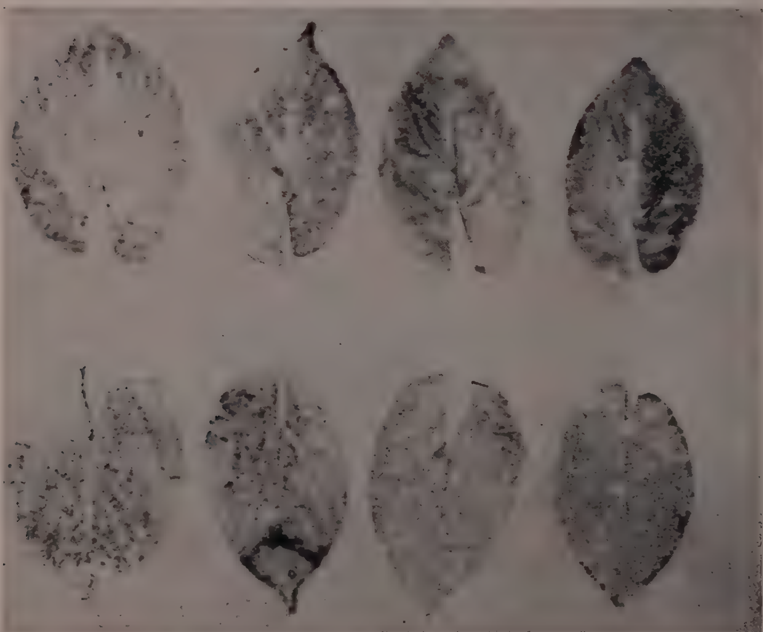

Fig. 2. Distribution of Dithane fungicide on potato leaflets that were sprayed with the low-gallonage, high-concentration sprayer. This picture was made using chemically treated filter paper to get a picture of the distribution of the fungicide.

TABLE 5

Extent of Foliage Coverage by Low-Pressure Sprayer

Type of Drop Pipes	Location of Sample on Plant	Average Extent of Coverage[1] (Scale 0 - 5)	
		Top Side of Leaflets	Under Side of Leaflets
Long Drop Pipes	Top	2.92	1.25
	Middle	3.55	1.20
	Bottom	2.65	1.23
Short Drop Pipes	Top	3.08	1.33
	Middle	2.92	0.42
	Bottom	2.18	0.27
No Drop Pipes (Brush Boom)	Top	3.08	2.50
	Middle	2.21	0.92
	Bottom	2.30	1.04

[1] Based on a scale 0-5 with 0 representing an absence of spray material to 5 designating complete coverage of the leaflet with chemicals.

a print of the distribution of chemicals. An example of these prints is shown in Figure 2.

The tests were made late in August after the potato vines had reached essentially maximum size. Growth was about average for that time of year but was not as large as might have been found in some fields. Samples were taken from rows not subject to wheel damage.

The upper side of all leaflets located near the top of the plants were well covered by each nozzle arrangement (see Table 5, note method of evaluation). However, the long drop pipes gave better coverage of leaflets at the middle and lower position of the plant than did the boom with short drop pipes or with no drop pipes.

It should be emphasized that these results were for plant conditions late in the growing season. To completely evaluate coverage from different nozzle positions and relate it to disease and insect control, further tests are needed throughout the growing season.

EFFECT ON YIELDS

A comparison of the yields for the two types of sprayers for the years 1950 to 1953 inclusive is given in Table 6. The data show that the high-pressure machine produced slightly larger yields for each of the four years that the experiment was conducted. However, the differences were not statistically significant (from 0.1 to 9.4 barrels, or 0.2 to 25.9 bushels per acre).

The fact that the high-pressure machine was tractor-mounted and the low-pressure machine was a trailer type and was drawn behind the tractor suggested that difference in the amount of wheel damage to the potato foliage might account for the differences in yield.

The comparisons of reduction in yield from wheel damage for the

TABLE 6

Comparison of Total Yields for Low- and High-Pressure Spray Machines
1950 to 1953

Year	Yield per acre					
	Low pressure		High pressure		Difference[1]	
	Barrels	Bushels	Barrels	Bushels	Barrels	Bushels
1950	206.9	569.0	209.1	575.0	2.2	6.0
1951	193.8	533.0	203.2	558.9	9.4	25.9
1952	150.9	415.0	153.0	420.8	2.1	5.8
1953	179.0[2]	492.3	179.1	492.5	0.1	0.2
1953	175.6[3]	482.9	179.1	492.5	3.5	9.6

No significant difference between yields of treatments.
[1] Difference in favor of high-pressure sprayer.
[2] Average of low-pressure trailer type of sprayer experiment.
[3] Low-pressure tractor mounted sprayer in 1953.

two types of machines for the years 1951 to 1953 inclusive is shown in Table 7. The low-pressure machine caused a significantly greater reduction from wheel injury in 1951 than did the high-pressure machine, the loss being 27.6 barrels (75.9 bushels) compared with 6.2 barrels (17.1 bushels) for the high-pressure outfit. During the early part of the growing season an exceptionally heavy rain caused considerable soil erosion in the test area. This left the ground between the rows rougher than usual. The greater amount of wheel injury for the low-pressure machine could have resulted from the wheels not running down the middle of the rows because of the rough ground.

TABLE 7

Comparison of Reduction in Yields by Wheel Damage
by High- and Low-Pressure Spray Machines
1951-1953

Year	Per acre loss from wheel damage[1]			
	High-pressure		Low-pressure	
	Barrels	Bushels	Barrels	Bushels
1951	6.2	17.1	27.6*	75.9*
1952	4.0	11.0	5.7	15.7
1953	15.0	41.3	8.6	23.6

* Significant at the 5% level.
[1] The wheels of the tractor and the trailing low-pressure sprayer injured one side of each of the four center rows of each swath covered by the sprayer outfit.

It can be noted from the data that in 1952 and 1953 there were no significant differences in the yield reduction that resulted from wheel injury by the two types of machines. The data therefore show that the trailer type sprayer need not cause greater injury to the potato rows than the tractor-mounted sprayer rig. Care, however, must be taken that wheels of the equipment are properly adjusted to the rows of potatoes.

CALIBRATION OF SPRAYER

To apply the desired amount of chemicals per acre it is necessary to calibrate the sprayer. The number of gallons per acre depends on:

1. Speed of travel
2. Pressure at the nozzles
3. Nozzle disk opening
4. Row spacing and number of nozzles per row

Speed of Travel. First, the desired speed of travel must be determined. On some tractors this can be read directly from a speedometer, though in most cases it will be necessary to make trial runs.

A convenient figure to remember is 88 feet per minute, which is equal to one mile per hour. A common travel speed for spraying is 4 miles per hour, or 352 feet per minute (4 x 88).

Where it is desired to find the throttle setting on the tractor that will come nearest giving a speed of 4 miles per hour, check the distance covered for one minute or part of a minute for each trial throttle setting. The throttle setting coming nearest to being 352 feet per minute will be the one to use.

If it is desired to find the exact speed in miles per hour (m.p.h.) for any given throttle setting, the following relationship may be used:

$$\text{M.P.H.} = \frac{\text{Distance traveled in feet}}{\text{Time in seconds x 1.47}}$$

Quantity of Spray Material. The factor most commonly varied on a sprayer to apply a given quantity of spray material is the operating pressure. The other factors affecting the quantity, which are the row spacing, number of nozzles per row, and the nozzle disk opening, are usually fixed.

The first step is to determine the gallons per minute (G.P.M.) discharge required per nozzle. This can be determined by the following formula:

$$\text{G.P.M. per nozzle} = \frac{\text{Row spacing in inches x gallons per acre x M.P.H.}}{\text{Nozzles per row x 5940}}$$

As an example, with 34-inch row spacing, using 3 nozzles per row and traveling 4 M.P.H., 0.19 gallons per minute are required from each nozzle to apply 25 gallons per acre. That is:

$$0.19 = \frac{34 \text{ x } 25 \text{ x } 4}{3 \text{ x } 5940}$$

The procedure for setting the sprayer to deliver the desired rate is as follows:

1. Set the pressure regulator at some trial position.

2. Collect the discharge from each of several nozzles along different points of the boom for a period of one minute.
3. Average the amount collected from the nozzles and see how it compares with the amount required per nozzle. If amount collected is less than amount required, increase the tension on the pressure regulator and if more, decrease the tension.
4. Repeat the above procedure until the average amount per nozzle collected on a trial run checks with the amount required.
5. Read the gauge pressure and maintain this pressure when operating.

The liquid collected from each nozzle may be more conveniently weighed than measured. Since a gallon of water weighs 8.34 pounds, the weight of liquid to be collected from each nozzle in the example above would be 0.19 x 8.34 or 1.58 pounds.

When the proper tractor throttle setting is once determined along with the correct pressure, the same amount of liquid should always be applied as long as those settings are maintained. However, since nozzle orifices gradually enlarge by wear, it is well to calibrate the sprayer every one or two seasons.

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